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AOARD REPORT

The Fourth Micro-Optics Conference and the Eleventh Topical Meeting on Gradient-Index Optical Systems (MOC/GRIN'93) 20-22 Oct. 93 at Kawasaki, Japan

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This report discusses the technical papers presented at the joint meeting of the Fourth Micro-Optics Conference and the Eleventh Topical Meeting on Gradient-Index Optical Systems (MOC/GRIN'93), held 20-22 Oct. 93 at Kawasaki, Japan.

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Subject: Trip Report - The Fourth Micro-Optics Conference and the Eleventh Topical Meeting on Gradient-Index Optical Systems (MOC/GRIN'93), 20-22 Oct. 93 at Kawasaki, Japan

Abstract

This report discusses the technical papers presented at the joint meeting of the Fourth Micro-Optics Conference and the Eleventh Topical Meeting on Gradient-Index Optical Systems (MOC/GRIN'93), held 20-22 Oct. 93 at Kawasaki, Japan.

Introduction:

MOC/GRIN'93, sponsored by the Japan Society of Applied Physics in cooperation with several academic societies and technical associations and organized by the group of Micro-Optics, the Optical Society of Japan, a branch of the Japan Society of Applied Physics, attracted close to 400 participants from Japan, the United States, the United Kingdom., Indonesia, China, Germany, Australia, Spain, France, the Netherlands, Hong Kong, Belgium, and Taiwan, of which the majority of participants came from the hosting country, Japan. The conference was held at the Kanagawa Science Park, located in the City of Kanagawa about 15 km West of Tokyo. This three-day conference brought two topical meetings, which were normally held separately at different times, together at one place this year to encourage interactions and exchange technical information among scientists who are active in areas of micro-optics and gradient-index optical systems. With 13 sessions, the joint three-day conference covered such topics as waveguide simulations & measurements, material properties of micro-optics, active micro-optics, applied micro-optics, polymer micro-optics, micro-optics sensors, and optical coupling & interconnects. Each session was carried out in succession so that everybody who attended the conference had a chance to listen to all the speakers.

As a whole, the conference was successful in bringing scientists together at one place for stimulating discussions. A special session on polymer micro-optics/GRIN optics was especially interesting in finding out the recent development of low cost polymer materials for uses in optical fiber-based photonics switches, optical lenses, and planar optical waveguides.

Comments/Observations:

1. The conference began with opening remarks by Dr. K. Nishizawa of Nippon Sheet Glass, Japan and Dr. U. Uchida of Tokai University, Japan. Following the opening remarks, Prof. Y. Suematsu, professor of Tokyo Institute of Technology, Japan, and Prof. W.A. Gambling, professor of the University of Southampton, UK, gave very informative talks on current technology of photonics and integrated fiber optics, respectively.

Prof. Suematsu's discussed the recent progress in the development of nanostructure devices where researchers have been actively involved in understanding quantum-well and strained-layer superlatttice structures of semiconductor photonic devices. As compared with many other semiconductor lasers, strained quantum-well lasers show the drastic improvement in optical gains due to the strained superlattice structure, which results in lowering the carrier concentration needed for efficient lasing. He identified three types of quantum-structures available for semiconductor devices: 1) the quantum-film, 2) the quantum-wire, and 3) the quantum-box. For these three types, the electronics state density of the conduction band is shown to decrease from quantum-film to quantum-wire, and then to quantum-box. As a result, the highest optical gain is expected from the quantum-box structure.

In last few years the rapid progress has taken place in this research area. At the present time, strained quantum-well film and wire lasers have been developed and their performance was well characterized. It's been reported that these laser have shown significantly reduced values for lasing currents. In the development of quantum-well wire lasers, there were many approaches explored up to the date. Approaches include lithography and etching, the fractional layer superlattice, the selective growth on V-shaped substrates, the edge quantum wire, and the strain-induced lateral layer ordering. On the other hand, not much progress has been made in the development of strained quantum-box lasers. One recent report done by Matsunaga and co-workers in 1993 shows that they have successful fabricated a strained quantum-box laser and demonstrated the lasing capability.

Prof. Suematsu also made a remark that based on the Quantum Confined Stark effect the quantum-well structure and strained-layer superlattice devices can be used for planar loss and reflection-types of switches and modulators. Already, there is a high speed planar loss-type modulator built for frequencies greater than 40 GHz. For the reflection-type, GaInAs/InP is used for the material and technology has developed to the point where it is possible to achieve the field induced refractive index variation of 4 to 7% in quantum-wire and quantum-box , respectively. It is significantly larger than that of the bulk crystals.

Also Prof. Suematsu discussed current technology in developing photonic integrated circuits for creating monolithic planar devices. As a novel method of fabricating active and passive monolithic devices, he proposed to use a selective MOCVD on patterned substrates.

As part of his concluding remarks, he re-emphasized the potential of using strained quantum well structures to create nanometer devices. There is much research that needs to be carried out in the near future.

2. The second plenary paper by Drs. Gambling and Wilkinson of the Optoelectronics Research Center, the University of Southampton, United Kingdom, contained an excellent up-to-date overview of integrated fiber circuits, dealing primary with telecommunications. The paper contained a bit of everything, starting with the development of optical fibers and devices. Major areas described were active optical fiber devices, passive optical devices, and new optical fiber materials.

In the area of active optical devices, the recent developments of fiber lasers, fiber amplifiers, and harmonic generation materials were discussed in some detail. The paper

pointed out that the advantage of optical fiber lasers rests on confinement of the high intensity pump radiation within a long waveguide tube, which results in higher population inversion than well-known lasers such as diode and semiconductor lasers. In particular, optical fiber lasers can convert poor quality, noisy optical output of a semiconductor laser into quiet single-frequency radiation. Also, optical fiber lasers have shown to produce higher pulse power than diode lasers. The power level up to 11o kW has been observed.

At present, Neodymium-doped fiber lasers operating at 1.3 microns and erbium-doped fiber lasers operating at 1.5 microns have exhibited single frequency operations. Under modelocking operations, it is possible for fiber lasers to produce 30 fs pulses which are suitable for spectroscopic applications, whilst in soliton systems, pulse repetition rates up to 200 GHz have been observed using dispersion-tapered fiber.

In the area of fiber amplifiers, erbium-doped fiber amplifiers (EDFA) have provided the polarization insensitive gain of more than 50 dB and output power of 0.5 W at wavelengths around 1.5 microns. Due to the ease of obtaining a high population inversion, the noise level may approach the theoretical minimum of 3 dB when pumped at 980 nm. The gain slope efficiency of an EDFA is typically of 11 dB mW of pump power. The EDFA can operate as s small signal amplifier, power amplifier, preamplifier, and power limiter, and its gain region can either be localized to a few meters or distributed along the entire length of the fiber.

For passive fiber devices, there are fiber couplers, acousto-optic modulators, in-line isolators and circulators, pulse shaping fibers, fiber grating, and tunable fiber Fabry-Perot resonators. Of these, pulse shaping fibers have attracted special attention due to the generation of ultra fast soliton pulses using the dispersion tapered fiber. In a recent experiment, two fiber lasers were used to create high quality 30 fs soliton pulses at a repetition rate of 200 GHz. Another area that showed the rapid progress was in fiber gratings. It has been shown that gratings with a reflectivity of 99.8% have been holographically written into the core of a germanium -doped fiber with a 20 ns ultraviolet pulse. They have exhibited linewidth as low as 6 GHz and as high as 920 GHz. Such gratings made possible for the creation of narrow-line fiber lasers, which can then be used for in-line fiber components of channel filters. In the past, gratings formed by polishing and etching fibers have been used for pump filtering and grain-shaping.

3. In this conference, for the first, the implementation of quasi-phase matching (QPM), second harmonic generation (SHG) devices using organic molecular crystals was reported on the generation of green light from frequency doubling the cw Nd:YAG laser light. The efficiency was reported to be 0.04 %/W of the input pump power. Although the efficiency is considerably lower than using inorganic materials, authors believe that it is possible to improve by further optimization of the device parameters, e.g., the refractive index and dimensions of the waveguide and use of other organic crystals having larger nonlinearity.

4. In the Active Micro-Optics/GRIN Optics session, a paper by researchers from the Tokyo Institute of Technology reported the first room temperature cw lasing of a 1.3 micron GaInAsP/InP surface emitting laser. When tested at 14 degree C, the threshold value was found to be 22 mA with the current density of 19 kA/cm^2. These values are comparable to that of commercially available edge emitting lasers.

5. In the special session of polymer micro-optics and GRIN optics, session chairpersons organized the session more in the panel discussion format with all seven speakers seated in front of the conference room. After the end of each presentation, a panel discussion was carried out to discuss any related issues pertaining to the paper just presented.

The session started with the invited paper by a group of researchers from AT&T Bell Laboratories. It discussed the use of low cost polymer materials for polymer waveguide photonics switches and polymer components such as polymeric splitters and combiners. The advantages of using polymer waveguide circuits and components are that interconnection costs are extremely low, signal splitting and combining can be done efficiently and cheaply, and active and passive devices for signal input and output are inexpensive. The typical limitations associated with polymer transmission path, i.e., high loss and signal dispersion, can be overcome by keeping path lengths short (<1 meter), which permits extremely high bandwidth capabilities at very low cost per path. As an example, the performance characteristics of a polymer-based photonic switch was described in some detail in order to show the feasibility of using polymer materials for optical components. When the switch was tested by transmitting 45 Mb/s video signals, no observable deterioration was seen in output signals. Although no mentioning of comparing the performance of polymer based switches with that of non-polymer based switches, this paper indicates that based on actual testing of polymer based switches it is possible to construct optical circuits with polymer materials.

Other papers in this session included the recent development of plastic lenses, the development of electro-optics devices based on optical nonlinear polymers, the development of polymeric planar optical waveguides with low optical loss (less than 10dB/m) in the infrared region, i.e., 0.8-1.6 microns, and the development of GRIN polymer materials such as GRIN lenses and high bandwidth, low loss GRIN optical fiber.

Summary:

This conference has successfully served to bring many of the world-class researchers who are active in micro-optics and gradient-index optical systems at one place.

Now, the future is not just in micro-optics. It seems that photonics research is heading into nanostructures. The quantum size effects are becoming more and more important as photonics devices become more compact. Also, we need to be abreast of the progress in integrated fiber optical systems used for communications.